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SECOND CONFERENCE on RICE UTILIZATION

Held at Albany, California
May 18-19, 1961

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THE FIRST CONFERENCE ON RICE UTILIZATION, held March 7-8, 1960, in New Orleans, Louisiana, was cosponsored by the Rice Millers Association and the Southern Utilization Research and Development Division of the Agricultural Research Service, U. S. Department of Agriculture. That its aim -- to acquaint the rice industry with past and present accomplishments in research -- was achieved was attested by the resolution proposed by William M. Reid of the Rice Millers Association, calling for the appointment of a rice industry committee to facilitate and promote research. This resolution was approved and a committee was appointed.

To further the stated objective, a second conference under the sponsorship of the Southern and Western Utilization Research and Development Divisions was scheduled for May 18-19, 1961, at the Western Regional Research Laboratory in Albany, California, headquarters of the Western Division. Personnel of Federal, State, and private agencies participated in this conference. Condensations of the proceedings are reported herein.

This report was prepared in the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Albany 10, California. Copies are available on request.

PROGRAM AND CONTENTS

UTILIZATION RESEARCH NEEDS OF THE RICE INDUSTRY

K. K. Keneaster
Uncle Ben's, Inc., Houston, Texas
(Chairman, Committee for Advancement of Rice Research)

It is a distinct honor and privilege to discuss with you a few of the utilization research needs of the rice industry. But first I want to express my thanks in behalf of the Rice Millers Association and the rice industry for all the efforts of the Director of this Division, Dr. M. J. Copley, and his group in arranging this meeting. Just a glance at the agenda is impressive, with its scope and listing of authoritative speakers. I also want to thank all these speakers who have made such a fine program possible.

Even though this is primarily a rice utilization research conference, I want to emphasize that sharp, neat boundary lines cannot be drawn between utilization research, production research, and marketing research. There is a certain amount of overlapping which is inevitable and proper, and the workers in each field should be cognizant of their relationship with the others. This observation is in no sense a criticism of past performance, but in speaking for the rice industry I want to urge all concerned to continue your diligent work in a spirit of harmony and cooperation with your fellow workers in other agencies so that the maximum rate of unfolding of the truth can be achieved. There is no room or reason for strife between researchers or administrators of research.

Now as to the utilization research needs of the rice industry, much of what I say will merely reiterate what has been said many times before by others much wiser than I. There are three broad areas of activity which I would like to recall to your attention: (1) reviews of research; (2) basic research on properties of rice; (3) applied research in improving present technology or replacing it with new technology. Let us take these in order:

<u>Reviews of research</u>: You researchers here and others who were unable to come have done much <u>good</u> work in the past on many subjects. Someone needs to be assigned the task of reviewing each major line of rice research and publishing a comprehensive report thereon to give researchers and industry a bench mark from which expanded research efforts can be launched. A good example of what I'm talking about is a report edited and arranged by Mr. Dachtler in 1959 on the conditioning and storage of rough rice. Although I'm a very poor example of what I'm preaching here, I find it quite useful and time saving if periodically I review what has gone before rather than rush on willy-nilly, not looking back. I know we are living in an impatient age but, as Sir Isaac Newton once said: "If I have ever made any valuable discoveries, it has been owing more to patient attention than to any other talent." Therefore, I feel that periodic comprehensive reviews of research would be extremely useful to all in the rice industry.

<u>Basic research on properties of rice</u>: Although much progress has been made in certain areas with respect to the fundamental composition and properties of rice, there are literally hundreds, even thousands, of specific questions which can be asked but which have no answers as yet. A concerted

effort to unfold the mysteries that surround this little grain of rice needs to be made so that we and future generations may make the most of it. Without an understanding of the basic properties of rice, advances in applied technology must of necessity eventually grind to a halt.

Applied research in improving present technology or replacing it with new: In this broad field certain of our committee members have expressed varied opinions as to the importance of certain fields of applied research but in general the consensus is that the following areas should receive the most emphasis: (1) improved procedures for the milling of rice, (2) objective measurement of rice qualities, and (3) large-scale profitable uses for rice hulls. Of lesser importance were the following areas: (4) development of rice protein supplements by concentration methods, (5) development of rice products for the paper, plastics and related industries, and (6) development of a rice enrichment method which will produce a more uniform rinse-resistant enriched rice at lower cost.

Those of the committee who responded to my solicitation of their remarks were unanimous in their feelings that the development of convenience foods from rice are more properly in the province of industrial rather than government research.

To summarize--there are three broad areas which need attention: (1) the publishing of comprehensive reviews of research in each of several lines of major rice research, (2) an intensified effort toward determining more of the basic fundamental properties of rice, and (3) an applied research program directed toward the solution of specific problems mentioned earlier.

THE NEED FOR A FLOURISHING UNITED STATES RICE INDUSTRY

Marshall E. Leahy
Farmers Rice Growers Cooperative, San Francisco
(Address presented at a dinner meeting, May 18)

Because rice is a vital factor in the international economy, the United States rice industry should be something more than just a residual supplier in the world market. Asia, the Far East and South America, where the United States is trying to win friends, are all heavy rice-consuming areas. The best interests of the United States in our defense program, in our foreign economic position, and in our Food for Peace Program require that the United States rice industry should be nurtured and even expanded.

Red China is obviously trying to take over the rice bowl of the world, principally Thailand and Burma, and if those two principal exporting countries

disappear from the world rice picture, the United States will be the largest exporting nation in the world rice trade. Because of these considerations it is imperative that the United States maintain a sound position in rice in the world market. This is further aggravated by the fact that CCC stocks are presently depleted to the extent that if Cuba should suddenly undergo a reversal in its relations with the United States we could not take care of its requirements in rice.

There is little or no uncommitteed rice surplus in the United States and while a great deal of that fortunate position is attributable to government donations, school lunch program and Public Law 480 programs, the industry itself is entitled to considerable credit, having done a great deal on its own. The California industry has developed a brown rice trade for dollars with West Germany, which is a new market. In 1958-59 the California rice industry exported 18,000 tons to West Germany and this year in the 1960-61 marketing season will export 35,000 tons to West Germany; this market has been developed by the California rice industry.

Additionally the United States rice industry has had a program under way for some years to increase the per capita consumption of rice. Each year since 1956 $400,000 per year has been spent on this project and a total of $5,000,000 since 1947. As a result, per capita consumption of rice in the United States has increased during the last ten years, whereas that of other foods of like type and variety declined during the same period.

Also the United States Rice Export Development Corporation has been operating for some years in setting up and activating, and in part financing, a number of projects throughout the world in the hope of increasing the exports. Presently this corporation has a three-way project going in 17 countries, primarily in Europe, involving the United States government, the United States Rice Export Development Association, and the German importers.

Much of the credit for progress in rice is attributable to government research. The Rice Research and Marketing Advisory Committee has done an outstanding job. Not so long ago it was impossible to find anyone in government or research who knew anything about rice. In the last ten years the government has developed an awareness of rice and its problems and it is now possible to find many competent people in government and research with a knowledge of rice and with a desire to do something to assist. Research programs for rice, particularly in utilization and marketing, were completely unknown not so long ago and now you have a number of fine programs under way in the Western and Southern laboratories particularly, as well as in other areas of research.

The industry recognizes that basic research is still needed but we are aware of the budgeting problem and the relative position of rice as compared to other commodities. While we recognize our limits so far as research funds are concerned, we must fight to see that rice receives its fair share. In the last ten years there have been great improvements in a number of phases of production, processing, and marketing, namely, drying, storage, insect control, diseases, new and improved uses, grading, inspection and marketing, all of

which had a direct and positive association with our rice research programs. Industry must recognize that research is slow and costly but it should bear in mind the old adage "Nothing is good that comes easy." Industry and research people must cooperate and coordinate their activities. It is up to industry to assist, to advise and to channel the research talents into the helpful areas.

RICE PROTEINS - I

Virginia R. Williams
Louisiana State University, Baton Rouge

The two most recent Louisiana State University studies on rice protein have dealt with (a) the variation in amino acid content of rice varieties and (b) the electrophoretic patterns of albumins and globulins extracted from several varieties of milled rice by special techniques.

In the amino acid study, Bluebonnet, Century Patna, Magnolia, and Zenith varieties were grown at four locations: the Louisiana Rice Experiment Station at Crowley, Brewer's Farm at Crowley, the Arkansas Rice Experiment Station at Stuttgart, and the Texas Rice-Pasture Experiment Station at Beaumont. Representative replicate samples of both brown and white rice were analyzed by standard microbiological assay techniques for the eight essential amino acids: lysine, methionine, phenylalanine, threonine, isoleucine, leucine, valine, and tryptophane. The following findings were reported:

(a) Rice varieties grown at the same location differed widely in their amino acid content.

(b) There was considerable variation in amino acid composition of the same variety grown at different locations.

(c) Milling caused a decrease in the crude protein content and also in the essential amino acid content of the rice grain, when expressed on a weight basis. When the amino acid content was expressed on the basis of 16 grams of nitrogen (or, roughly, the total protein), amino acids responded differently to milling treatment. For all four varieties at the four locations, the average content of isoleucine, leucine, and valine increased upon milling. The average content of lysine, however, decreased upon milling, whereas the average content of methionine did not materially change. Results for the other amino acids were variable. It may be inferred that the nature and distribution of proteins within the rice grain are not uniform.

(d) Rices grown at the Arkansas Station had a low nitrogen content but their essential amino acid content approached or even exceeded that of

high-nitrogen rices. Magnolia brown rice grown at different stations also exhibited generally a reciprocal relationship between the content of nitrogen and the content of essential amino acids in the grain. Different varieties grown at the same location showed the same effect, but the variation was more consistent and pronounced in the case of the same variety grown at different locations. The effect was generally noticeable with respect to all the amino acids tested but was less definite in the case of tryptophane and methionine. Similar findings have been reported in the literature for corn and wheat.

(e) One must conclude that many factors are operating which are effective in modifying the content of crude protein and amino acids in rice.

In the second study, we attempted to extract the water- and salt-soluble (5% sodium chloride) proteins of Caloro, Zenith, Rexoro, and Century Patna varieties without denaturation resulting from manipulative procedures. These extracts were carefully lyophilized and then redissolved in the appropriate buffer so as to obtain concentrated protein solutions. The resulting solutions were then subjected to electrophoresis on starch plate at low temperature. Proteins were located on the starch bed by sectioning the plate, extracting the protein with buffer and reading the optical density of the extracts at 280 mu. Examination of the resulting electrophoretic patterns showed most of these fractions to be quite heterogeneous, generally isoelectric around pH 7, and otherwise dissimilar. This study is being extended and checked to verify the original findings.

RICE PROTEINS - II

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Western Regional Research Laboratory
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The interest of the Western Regional Research Laboratory in the cooking, processing, and nutritive qualities of rice has recently been further implemented by initiation of studies on rice proteins. Their possible effects on the properties of rice can be indicated by the fact that proteins are composed of the nutritionally important amino acids, and also that it is the protein of wheat which gives baking properties to flour.

Information available on rice proteins is less than on proteins of other cereals, but it does show that rice differs in having greater proportions of its protein in the class called glutelins. These are the most difficultly soluble proteins and dissolve only in dilute acids or alkalis. To this class

also belongs the protein of wheat, glutenin, which is so important in baking quality. The remaining rice proteins fall chiefly in the salt-soluble group, the globulins.

Most of the protein information here reported is the work of Miss Norma Alfonso Hernandez, who is studying here on a grant from the Mexican Institute of Technological Investigations in Mexico City.

Rice proteins were extracted by three methods. The long-established procedure of extractions in sequence by salt solution, aqueous alcohol, and dilute alkali was used as the reference method. This procedure removes about 65% of the total protein (15% as globulins and 50% as glutelin). Two other extractions yielded 90-95% of the protein. One, using detergent, has not been further examined, as detergent was very difficult to remove. The other, using an alkaline solution containing copper, was highly effective. Whether or not it changed the protein during extraction requires more study.

Glutelin from dilute alkali was of good purity and was essentially free of contaminating phytin or nucleic acids. The copper extraction method yielded glutelin of like purity.

Study of the movement of alkali-prepared glutelin in solution under an electric current (electrophoresis) showed the material traveling as a single component. It appeared, however, to be a group of closely similar substances rather than a single compound. The copper-method glutelin in the same test showed two components, suggesting the protein had undergone some change. Corresponding electrophoretic tests on the globulin fraction showed at least two components were present.

Attempted separation of the globulins with weakly basic ion exchange resin was unsuccessful. However, separation on an acid resin, carboxymethylcellulose (CMC), provided a fore-run and four subsequent components. They comprised 14, 7, 22, 41, and 16% of the total recovered material. Further characterization will show how these compare with the four globulin components found in other cereals.

The results obtained in the experiments to date show that adequate techniques are available for separations and characterizations of rice proteins and should enable us to determine much about their role in modifying the cooking and processing properties of rice.

RICE STARCHES AND AGING OF RICE

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A large sample of foundation rice seed, Bluebonnet-50 of known cultural history, was divided into two lots of approximately equal size. One lot was held as rough rice at ambient laboratory temperature and the other as rough rice at 4° C. (39.2° F.). Subsamples from each were milled and analyzed at frequent intervals for chemical composition, such as the determination of amylose, starch, protein, surface lipids, and total and reducing sugars.

In addition special tests designed to correlate objectively and subjectively the changes in processing and cooking characteristics of the rice were applied. These include water uptake of the whole milled rice, quantitative estimation of the losses of solids and solubles to the cooking water and analysis of these for starch, amylose, protein and sugars, determination of the birefringence end-point temperature, alkali number, Zeleny protein precipitation test, protein solubility in saline solution, viscosity and pasting characteristics as determined by the Brabender Viscograph, and cooking tests to determine culinary properties as influenced by aging.

The Brabender (viscometric) characteristics of both the low-temperature and ambient-temperature samples have been found similar in pattern, except that values have progressively increased during the period from October 1960 to April 1961, thus indicating gradual change in chemical and/or physical properties of the kernel. Decreases in water uptake at 70° and 90° C. (158° and 194° F.) have occurred during the same period; the sample at ambient temperature showed the greater change. Although values of the Zeleny sedimentation test have remained constant, the supernatant liquid is now clear rather than cloudy as when originally tested. Total starch, nitrogen, amylose, surface lipids, and nitrogen solubility in saline solution remained almost constant during storage at both temperatures. Both samples exhibited birefringence end-point temperatures in the range of 70°-73° C. (158° and 163° F.). The composition of the solids and solubles lost to the cooking water at 90° C. (194° F.) does not reflect significant trends in protein, starch, and sugar contents. However, differences in the appearance of both samples are apparent inasmuch as they are less "tacky" now than when initially treated in October 1960. As previously observed, the material lost to the cooking water is a solid gel rather than the sticky, water-like pectin substance initially observed.

EFFECT OF PREPROCESSING HISTORY ON PROCESSING QUALITIES OF RICE

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In tests of Caloro and Calrose varieties, the composition and physical properties of rice were shown to be influenced by cultural and environmental factors. During maturation, paste viscosity, water absorption, and lightness of color of milled samples reached minimum values, and yields of head rice reached maxima in the approximate range of 25 to 32% harvest moisture. Then a reversal of trends took place. High amylolytic activity was observed at the low point in the viscosity curves, and vice versa. Spectrophotometric measurements indicated that chlorophyll disappeared shortly after the high or low points in the curves. Protein showed some reduction between initial and terminal samples, but the greatest loss (in Calrose) was less than 1% on the basis of the rice. Other constituents such as crude fat, fiber and ash also declined as maturity proceeded, whereas total starch increased proportionately. Light transmitted through a layer of rice of definite thickness was found to be a fair but not an exact measure of the content of kernels, which were at least half chalky. Chalkiness decreased while light transmission increased during maturation.

Rice grown at various rates of nitrogen and phosphorus fertilizer from zero to 60 pounds of phosphorus and 80 pounds of nitrogen per acre showed an increase in nitrogen of milled samples as a result of the nitrogen treatment. At the 80-pound rate, some samples were about 50% higher in nitrogen than the controls which had had no fertilizer. Increased nitrogen content was accompanied by lower hot paste viscosity, water uptake, and kernel weight, and in most instances by a lower lightness factor in color measurement. Yields of head rice in a standard milling test were not affected significantly by the fertilizer treatment. The effects of phosphorus as an individual factor were not conclusive in a statistical analysis of data, and there was no significant evidence of interactions.

The influence of the farm factor became apparent in these studies. As an example, rice grown on two farms of the same soil type and under identical applications of fertilizer showed consistent differences in physical properties. A reason for this variation may be that one farm had been planted to rice the previous year, whereas the other had lain fallow.

Storage of milled Caloro, Rexoro, and Bluebonnet rices at room temperature and 100° F. increased hot paste viscosity of rice flours, with higher rate of change being shown at the higher temperature, as would be expected. The same rices stored at 34° F. showed little or no change in this respect.

FOOD QUALITY FACTORS USED IN RICE-BREEDING STUDIES

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Crops Research Division
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Rice production research in the United States deals primarily with the development of varieties and cultural methods that meet the needs of producers, processors, and consumers. Such studies cover a diversity of problems related to cultural practices and physiology, disease control, and the development of improved varieties. I will discuss only the breeding work dealing with the milling, cooking, and processing characteristics. Although cooperative rice-breeding studies are conducted in the principal rice-producing states, the quality phases of the work are done primarily in our rice quality laboratory at Beaumont, Texas.

It is essential that new varieties possess the quality characteristics generally associated with each grain type. Thus one of the principal objectives of the breeding program is to standardize the chemical and physical characteristics of the varieties within each type. When the rice quality laboratory was established at Beaumont in 1955, there was some knowledge of the physical and chemical characteristics associated with cooking and processing behavior. Many factors, however, were not known, and methods were lacking for applying what was known in the study of the large number of samples required in a breeding program. During the past 6 years, much progress was made in determining ways of defining cooking and processing characteristics of rice and developing methods to test large numbers of samples. Methods currently used are based on results from other laboratories in the United States and from foreign countries as well as on results from the Beaumont laboratory.

Factors known to be associated with cooking and processing characteristics are amylose content, gelatinization temperature, and pasting characteristics of the starch. It is suspected that variations within the amylose and amylopectin fractions of the starch, and the protein and lipid contents also, may influence cooking and processing behaviors but their functions are not known.

The tests most commonly used to determine the amylose content, gelatinization temperature, and pasting characteristics of breeding lines are as follows: (1) Amylose content is determined by the iodine method, and samples that have a dark-blue color in this test are analyzed quantitatively. (2) Gelatinization temperature is determined by the granule swelling, birefringence end-point temperature, and the Brabender Amylograph methods. Information on this characteristic is obtained also by the alkali method, by water uptake at 77° and 82° C. (170° and 180° F.) and by the heat alteration method. (3) The pasting characteristics are determined with the Brabender Amylograph.

Other tests used to differentiate the breeding lines as to their cooking and processing characteristics are as follows: (1) Soaking test, which consists of soaking cooked rice in cold water overnight and noting the degree of splitting of kernels. (2) Parboiling test to determine the suitability for canning and other processes.

Varieties that cook dry and flaky and are suitable for canning, quick cooking, and similar processes are high in amylose, have an intermediate gelatinization temperature, and the viscosity is lower at 94° C. (201° F.) than when cooled to 50° (122° F.). Varieties of this type also show little splitting and fraying of the kernels in the soaking and parboiling tests. These characteristics are generally associated with long-grain varieties.

Most medium- and short-grain varieties usually are moist and somewhat cohesive (adhesive) when cooked. They are used as table rices and by the brewing industry and for making dry cereal products. These varieties are somewhat lower in amylose and have a lower gelatinization temperature than long-grain varieties, and their viscosity is usually higher at 94° C. than at 50°.

The milling quality of breeding lines is determined by a method similar to the one used by the grading service.

RICE AND THE UNICEF PROGRAM

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United Nations International Children's Emergency Fund
New York City

Originally known as the United Nations International Children's Emergency Fund, UNICEF was established by the United Nations General Assembly in December 1946 to give relief to children, primarily in war-devastated countries.

The General Assembly in 1950 extended UNICEF's life for three years, and directed a shift in emphasis from emergency aid to programs of long-term benefit for children in economically underdeveloped countries. In 1953 the General Assembly voted to continue UNICEF indefinitely. The name was shortened to the United Nations Children's Fund. UNICEF is a part of the United Nations, with a semiautonomous status. It is governed by a thirty-nation Executive Board which meets regularly to set policy, consider requests, allocate aid, evaluate results, and establish the annual administrative budget of the Fund. The actual day-to-day operation of UNICEF is the responsibility of an Executive Director, who is appointed by the Secretary-General of the United Nations in consultation with the Executive Board.

The speaker continued with a series of comments and questions concerning the use of rice in the general problem of providing nutritionally adequate infant foods. The emphasis is on infant foods for use in those areas of the world where kwashiorkor (a protein-deficiency disease) and malnutrition are prevalent. The supplementation of rice diets with high protein products of

indigenous origin, such as coconut, soya and leaf protein, was discussed--along with the possible use of rice flour fractions having high protein content. The need for fat, sugar, minerals and vitamins to complement rice and so provide a balanced food was mentioned and finally the need for simple processing and cheap packaging consistent with the present economic levels and purchasing ability of the average family. The economic and acceptability factors are as significant as the nutritional problems; these may limit the practical use of food supplements subject to extensive extraction and isolation techniques, if means are not found to surmount such obstacles.

QUALITY EVALUATION STUDIES OF DOMESTIC AND FOREIGN RICES

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The Foreign Agricultural Service in 1957 began a project which represents a first step toward defining the kinds of rice that move in international trade and the kinds preferred by consumers in importing countries. Its goal is to help establish some basis for comparing the competitive position of a particular rice in a particular market. Lack of international grades in rice as well as any semblance of a worldwide international market have always made this comparison difficult.

This project has embraced a two-part study on nearly 600 foreign rices, which were obtained by FAS during 1958 and 1959 in 31 countries representing 14 exporters and 17 importers. For the first part of this study, analyses were done by the Agricultural Marketing Service laboratory at New Orleans to evaluate these foreign rices in terms of U. S. grade standards. In March of this year, FAS published the results of this first part under the title "Analysis of Selected Varieties and Grades of Rice Moving in World Trade" (Marketing Research Report No. 460, FAS, USDA).

The second part of this investigation was undertaken under a cooperative agreement between ARS and FAS in which detailed chemical and physical quality evaluation studies have been conducted on these 600 foreign rices by the Western and Southern Utilization Research and Development Divisions, the Crops Research Laboratory at the Rice-Pasture Experiment Station (Beaumont, Texas), and the Food Quality Laboratory of the Institute of Home Economics (Beltsville, Md.). Sixteen types of U. S. rices (short, medium, and long grain) were included for comparative purposes. Both objective and subjective test methods have been used in these studies.

The ARS laboratories made subjective and objective determinations under the following categories:

Physical Characteristics: (1) kernel dimension, (2) weight per hundred kernels, (3) shape, size and appearance, (4) color.

Physical Tests: (1) gelation temperature, (2) alkali spreading, (3) alkali clearing, (4) water uptake and insoluble solids at 77° and 82° C., (5) Cooking quality characteristics (appearance, cohesiveness, tenderness, and flavor), and (6) heat alteration.

Chemical Analysis: (1) lipids (surface and total), (2) protein, (3) moisture, (4) fiber, (5) ash, (6) starch (total, amylose, amylopectin, amylopectin ratio), and (7) iodine blue.

Statistical analyses (in cooperation with Biometrical Services) and other studies are currently being made on these 32 variable quality factors. For these studies the samples have been classified according to (a) country, (b) grain length (long, medium, and short), and (c) product types (raw, parboiled, and glutinous). Average values and standard deviations are being determined for each variable. All correlations of any possible value--total of 2,925 sets of correlations--are being computed. From this, significant and highly significant correlations will be studied further.

It is anticipated that these studies will indicate what present testing methods need improvement or replacement by new procedures and that objective evaluations can be substituted for some, at least, of the subjective procedures. Results of this phase of the comprehensive study on foreign and domestic rices will be published in the near future. The technical data also will be utilized by FAS and other USDA agencies in helping to determine the best ways to market U. S. rices abroad and to guide development of rice production most suitable for this purpose.

GAS PLASMA IRRADIATION OF RICE AND RICE PRODUCTS

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The effect of "glow discharge" was first demonstrated at the Southern Regional Research Laboratory by T. E. Hienton of Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md. He showed that great changes were induced in water absorption of cellulosic materials and certain seeds when exposed under vacuum to an electrical discharge.

Preliminary experiments in cooperation with the Agricultural Engineering Research Division, Knoxville, Tenn. on long- and medium-grain milled rice seemed to parallel these results.

In these tests the Southern Laboratory's standard technique for water-absorption determination was used. The effect of time, current intensity, and degree of vacuum were then studied. The degree of vacuum had only a minor effect while current intensity and treatment time produced progressive increases in water-absorption values. Since the vacuum control actually cooled the rice, whereas irradiation induced higher temperatures, the possibility existed that the results were due to the heat and vacuum incidental to the irradiation procedure.

To test this possibility, the irradiation tube was jacketed so that the temperature could be accurately controlled by means of hot water or steam. Milled rice under constant temperature, with and without glow discharge, showed no differences. Water-absorption and cooking-test results were practically identical, showing the effect was induced by the heat-vacuum treatment. Cooking tests, rated by a panel for doneness, flavor, odor, and appearance, showed that when rice was presoaked for 20 minutes, the cooking time was reduced to 6 to 7 minutes, but little change was effected on the total cooking time required when the rice was cooked in an excess of water without presoaking. The effect on milled rice was probably a physical change in the kernel induced by minute fissuring throughout the grain, since paste viscosity and enzyme susceptibility were not altered.

Brown rice, however, showed very marked changes when irradiated. The development of free fatty acids during storage was definitely inhibited. When the bran was removed and extracted, the oil proved to be much more insoluble. Fresh rice bran when irradiated showed a marked inhibition in free fatty acid formation, less oil extractable by hexane, lowered iodine number, and increased molecular weight. These changes were due to irradiation *per se*, since vacuum-heat controls were not changed. Gas plasma irradiation, therefore, may be an excellent tool for a study of milled rice. New developments on the effect of glow discharge on rice bran and oil may be expected.

SHELTER FOOD AND QUICK-COOKING PRODUCTS

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USDA, Albany, California

Parboiled rice expands several fold when exposed to a stream of hot air to yield a crisp friable product with numerous small voids which allow it to imbibe liquids rapidly. These characteristics have given direction to new product development, including a cereal-based ration for fallout shelters.

In the formulation of shelter rations it was found that the above-mentioned characteristics could be retained when the materials were compressed into wafers along with suitable nonaqueous binders such as high melting-point fats and dry malt extracts. We attempted to incorporate in these wafers a texture and flavor that would permit use with different types of spreads, or crumbling and use with milk and sugar as breakfast cereal, or with a variety of hot sauces and gravies for a main dish. Their ready-to-eat form and bland palatability make them suitable when necessary as the total ration.

Two shelter tests demonstrated both the versatility and acceptability of the cereal wafers. Expanded wheat constituted the cereal base of the wafers made for the shelter tests; however, expanded rice could have been used.

Two convenience foods based on air-expanded rice are also under development: one a quick-cooking dry rice, the other an instant-cooking rice cereal. Both products can be prepared for the table by adding boiling water and allowing to stand 1 to 2 minutes.

General processes for the products have been worked out; however, certain details of processing conditions are still under study. Preliminary studies on gelatinization, or parboiling, indicate the process of gelatinization of whole-kernel cereal grains is a complex and little understood one. Studies are continuing in the hope of clarifying this process to help define optimum process conditions for the above-mentioned products and to aid in developing other novel and convenient foods for both domestic and export markets.

PROPERTIES OF RICE PRODUCTS DESIRABLE FOR BABY FOOD FORMULATIONS

Vincent Kelly
Gerber Products Company
Oakland, California

Various products made from rice are used in baby food formulations and cereals. Our primary concern is that these products are free from filth, weed seeds, insect fragments, and the like, and that they are processed under sanitary conditions. Secondarily, we consider their cooking properties.

To meet these requirements we must work in complete accord with our suppliers. Our understanding of their problems and their understanding of ours results in the best possible quality of ingredients.

Rice is a world-wide commodity and shows great diversity in properties, due to locality of production and variety. These variations significantly affect the production of baby foods.

Since rice is a hypoallergenic cereal, it is a particularly useful infant food. It is also valuable because of its content of linoleic acid. Linoleic acid has been shown to be essential in the diet, since it is not synthesized in the body. In our rice cereal product, linoleic acid is obtained from rice polish and rice oil.

The gelatinization temperature of the rice starch granule is of critical importance in the production of rice cereal, affecting the yield and quality of the product. The lower this temperature, the better the final product. A number of factors affect the gelatinization temperature. Variety is of great importance. Most short and medium grain rices gelatinize at a low temperature between 142° and 150° F. A great effect is also produced on this temperature by both particle size and free fatty acid level.

The stability of formulated baby foods containing rice flour as a thickening agent is related to the gel characteristics or amylose content of the rice flour. Severe water separation will develop during storage when rice flour milled from most long-grain rice varieties is employed as a thickening agent.

Short- and medium-grain rice varieties are preferred for use in baby-food products. Long-grain rice is undesirable, since product quality and production are impaired because of the high amylose content and high gelatinization temperature.

RICE ENRICHMENT - I

E. J. Lease
Food Technology and Human Nutrition Department
Clemson Agricultural College, Clemson, South Carolina
(Read by Clinton L. Brooke in Dr. Lease's absence)

While Louisiana and South Carolina have the two highest per capita consumptions of rice in the United States, it is probable that individuals in families of foreign extraction in New York City and the larger cities of California eat the most rice. Actually the figures for per capita consumption for a whole state are meaningless insofar as public health is concerned, because rice consumption varies greatly from one area to another within a state. In Charleston, So. Carolina, rice is eaten twice each day, whereas in another part of the State rice is eaten only twice a month.

When rice is an important staple food in the diets of low-income people it becomes a responsibility of the government to improve the nutritional quality of the rice or the diets or both. The State of South Carolina met that responsibility and requires by law that all rice sold within its borders shall be enriched. Puerto Rico passed a law requiring the nutritional improvement of rice a few years before South Carolina. Both laws were sponsored by nutrition leaders.

In 1958 the Federal Food and Drug Administration promulgated a standard of identity for milled rice (except rice coated with talc and glucose and known as coated rice) with nutrients added in specified amounts (Federal Register vol. 22, No. 166, p. 6887, Aug. 1957, and Feb. 25, 1958, p. 1170). Fortified rice destined for Puerto Rico even if coated was exempt from the requirements by a Food and Drug administrative extension, but when the Puerto Ricans migrated to New York City, millers found it illegal to supply them with the rice to which they had been accustomed. The Federal Food and Drug Administration withheld the sale of the rice because to date there is no standard of identity promulgated for enriched coated rice. Since it is legal to sell coated rice, but not enriched coated rice, millers stopped enriching. Enriched rice is legal, coated rice is legal, but enriched coated rice is not legal.

The talc and glucose can be washed off the rice and the presently used rinse-resistant premix which contains thiamine, niacin, and iron but not riboflavin will withstand the washing. These enrichment ingredients are retained in the rice after it is washed vigorously in cold water. Talc is hydrous magnesium silicate and is inert. Neither the talc nor the glucose reacts with the enrichment ingredients in any way. Some may question whether it is necessary to wash off the talc before cooking because the 1 percent or less of talc on the rice does not make the wash water any more milky or have any effect on cooking qualities. The question also arises as to whether the coating of rice is in the interest of the consumer or whether it is an added unnecessary expense and deception.

Coating with talc and glucose to change the appearance of rice has been practiced for well over a half century but justification for continuing the practice in the interest of the consumer is needed at the present time. In

1907 the Federal government began enforcing its ruling that coated rice must be labeled, "Coated with talc and glucose. Remove by washing." In recent years the old burlap sack has given way to the consumer-sized package of cellophane and paper. Millers are now able to produce rice so clean that it does not need to be washed before cooking. The 1956 South Carolina rice enrichment law permitted millers who marketed clean rice in sanitary packages to save half the cost of enrichment by using a powdered mixture of the vitamins and iron and labeling, "Do not rinse before or drain after cooking." The Federal standards for enriched rice issued in 1958 also permitted the use of non-rinse-resistant enrichment if the rice was prominently labeled, "To retain vitamins do not rinse before or drain after cooking." Obviously a package of rice cannot be labeled "to wash" and also "not to wash" and so the powdered premix method cannot be used for coated rice. The Federal law does not permit any type of enrichment of rice that is coated with talc and glucose.

Coating rice with talc and glucose is less important to the rice industry today than it was at one time. When rice was retailed from open bins, customers could see the shine imparted by the coating, but in cellophane bags rice shines on the supermarket shelf even when not coated. The modern homemaker wants "convenience foods" and has no time to wash off dirt or talc before cooking. Today rice is fumigated with such compounds as methyl bromide and hydrogen cyanide. Therefore, the questionable partial protection from insect infestation imparted by coating with talc and glucose is less important than it was a half century ago when fumigation was uncommon.

Further study shows that if an enriched staple grain food for which a Federal standard has been promulgated has any vitamins or minerals added and claimed on the label, it is purported to be enriched and must meet the standard for enriched or it is misbranded according to Federal law. Enriched means containing nutritionally significant amounts of riboflavin as well as thiamine, niacin, and iron. Enriched rice has been temporarily exempt from having riboflavin as a required ingredient. Three distinctly different methods for the riboflavin enrichment of rice have been subjected to some investigational research. None of these three methods would be satisfactory for the enrichment of coated rice because none has rinse resistance.

RICE ENRICHMENT - II

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Although the enrichment program was initiated 20 years ago, rice was the last of the principal cereal grains to be enriched. North Carolina established a law requiring rice enrichment in 1956, but a Federal Standard of Identity was not promulgated until 1958. Since that time an increasing share of the packaged rice sold in the United States has been enriched, chiefly with a non-rinse-resistant powdered mixture of vitamins and iron applied to the entire body of the rice, but also with a rinse-resistant "premix" consisting of kernels of milled rice which have been covered with vitamins and iron and then made resistant to washing by applying a protective coating. Such vitamin-enrobed kernels are admixed with milled rice at the rate of 1 in 200.

A principal obstacle to the enrichment of rice by either method has been the yellow color of riboflavin. This vitamin has been withheld from the Federal Standard of Identity as well as the North Carolina Enrichment Law. In the powder method, incorporation of a mixture including riboflavin causes a slight yellowing which is acceptable to the consumer but is looked upon with misgiving by some rice millers. If riboflavin is included in the premix method, the yellow color from the vitamin-enrobed kernels diffuses into the immediate surroundings when the rice is cooked in water, causing unsightly splotches in the cooked rice.

Both process research to facilitate dispersion of riboflavin from premix kernels and consumer education to stress the nutritive significance of the yellow coloration are urgently needed. It is estimated that 50 percent of the packaged rice consumed in the United States is currently being enriched with powder. Most of this does not include riboflavin. Possibly 10 percent of the bag and bulk rice is enriched with premix. Exports to Puerto Rico, all glucose and talc coated, amounting to approximately 300 million pounds annually, are 100 percent enriched with rinse-resistant premix not including riboflavin.

NEW FOOD PRODUCTS FOR DOMESTIC AND OVERSEAS USE

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Development of new food products to expand rice consumption is highly desirable for continued vigor of the U. S. rice industry. New convenience products will help to increase domestic use of rice, but radical new products would be more useful to stimulate overseas consumption in markets where assistance programs are not in effect.

New domestic products should feature the ultimate in convenience. Canned main-dish products, such as jambalayas and curries, or desserts that require lengthy and skilled home preparation are ideal for new convenience items. Advantage should be taken of the increasing popularity of Chinese foods by development of appropriate companion items, such as fried rice.

The practical availability of rice flour fractions containing from 15 to 20 percent protein would permit consideration of milk-like products designed for use by children in rice-eating countries with developing economies. Supplemental fats and proteins for such products could be obtained from rice bran and polish by either wet or dry (air-classification) processing methods. Expanded or plain parboiled rices and rice flours can also be combined with wheat gluten for production of inexpensive meat-like and sausage-like products for sale in dollar market areas short of animal products.

Exploratory work by the Western Utilization Research and Development Division has demonstrated the feasibility of such products, but additional work is needed to develop the technology required. Assistance of foreign scientists and technologists would be essential for tailoring of textures and flavors to local preferences in each country.

EVALUATION OF WRRL DRYING METHODS ON SOUTHERN RICE

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Plans have been initiated with the Louisiana Agricultural Extension Service to expand the use of rice drying and testing procedures that were developed at the Western Regional Research Laboratory. This proposed expansion is a result of mill-scale tests conducted at two Southern rice mills during two rice-drying seasons in cooperation with personnel of the Southern and Western Utilization Research and Development Divisions.

The following is a summary of the work conducted on Southern rice. Most of the information obtained will be used as a basis for planning the proposed agricultural extension rice drying work. Tests conducted at the first of two mills showed that with medium-grain Zenith rice, feed rates could be increased by more than 35 percent by use of air at 130° F. Calculations showed that drying costs were reduced by 2.2 cents per hundredweight or 3.5 cents per barrel. There were some small gains in milling yields; however, they were considered to be within the limits of experimental error. Tests were also conducted with long-grain Bluebonnet 50 rice in which increased capacity of approximately 20 percent was obtained by using air at 140° F.

At this mill it was also shown that the necessary control test operations could be satisfactorily conducted by dryer personnel. The improved procedure was subsequently adopted by the plant management. It has proved profitable and they plan to continue its use during the 1961 season.

Drying tests conducted at the second mill on Bluebonnet 50 rice showed that the operating conditions were near optimum. In a series of seven test runs, drying temperatures and the number of passes were varied. Drying rate increases up to 54 percent were obtained; however, head yields decreased as much as 3 percent. For example, a 33 percent rate increase resulted in a 1 percent decrease in head yields as compared with the control. At the point where there was no decrease in head yields, the feed rates did not increase.

Another series of tests was conducted at the second mill to evaluate sampling and testing procedure. These tests were necessary because this mill was more advanced than the average mill from the engineering and mechanical viewpoints. Results of a series of tests conducted on a basis of statistical design showed that (1) the milling variability of similar rice samples dried on different days is detectable, (2) milling results vary from day to day, (3) there is a detectable, sometimes sizable variability in duplicate samples caught from the process stream, and (4) milling results may differ with different operators. Determination of these variabilities enables the design of a more efficient experimental procedure for studying rice drying.

These data show the need for careful planning in the conduct of control tests to minimize milling variations. For example, to minimize the effect of milling on different days, samples from a series of test runs, such as one including a control and three drying temperatures, should be milled within a

24-hour period. If this is not possible, comparative samples in the order of importance from the series should be run on the same day. For example, for each drying temperature a complete series of samples including one for each pass should be milled on the same day by the same operator, since it is the difference between the milling yields of the green rice and the rice after the last pass that is important. If a second series of samples is milled on another day by another operator, any variation should be constant for each sample and therefore the difference between the yields of green and final rice should be comparable to the first or any other drying temperature series.

Some laboratory-scale tests on low-moisture milling were conducted also, as part of the study on drying of long-grain Bluebonnet rice. This study showed that moisture significantly affects milling yields. For example, over a range of 14 to 10 percent moisture, for each 1 percent decrease in moisture, head yields increased about 3 percent and total yields about 0.7 percent. Indications are that the gain in total yield may be due to removal of less polish.

Moisture regain of rice milled to low-moisture content is important from the standpoint of economics and quality. Limited laboratory-scale tests in which U. S. No. 1 milled rice was subjected to a relative humidity of 86 percent and a temperature of 77° F. showed that rice with 10 percent moisture will regain water to a 12 percent level in 5 hours with no apparent change in quality.

With the exception of low-moisture milling and moisture regain, information such as ability of dryer personnel to conduct tests, method of sampling, planning of milling tests, and the general procedure as developed by the cooperative work will be used in planning the initial agricultural extension work on drying of Southern rice.

LOW MOISTURE MILLING

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Rice breakage was reduced in commercial mills and laboratory appraisal mills when the moisture content of California Pearl short-grain paddy was lowered. To offset reduced weight of products from rice milled at low moisture content, head rice was rehydrated to conventional moisture level without appreciable cracking, increase in chalkiness, or change in color. Laboratory milling yields were increased when paddy was milled immediately after drying.

<u>How Rice Moisture Content Affects Milling Yields</u>. Rice moisture content was found to affect milling yields appreciably in the official USDA appraisal method. The magnitude of the change varied for different years and varieties, but higher yields always accompanied lower moisture levels. For each 1 percent decrease in moisture in the range 10-14 percent, yields of total milled rice increased 1.2 percent and yields of unbroken kernels increased 1.8 percent in one series of tests. On the basis of these figures, drying to 11.5 percent instead of the usual 13.5 percent moisture could increase product value of California rice by $3.5 million yearly if the milled rice were remoistened. However, these milling results were obtained with a laboratory mill that differs from the commercial mills in both design and operating principle.

Plant-scale tests were made to determine how moisture affects yields in commercial mills. Three 4,000 cwt. lots averaging 13.1 percent in moisture content were each divided into two equal parts. Half of each lot was dried under mild conditions to an average of 11.4 percent moisture, and tempered for 1 week. Each half-lot was then milled separately and to the same degree. The change from high-moisture to low-moisture paddy required only a small tightening of clearance plates in the mills, which increased milling time 8 percent. Although rice breakage during milling was reduced by the additional drying, milling yields and value of milled rice were disappointing. Value of the milled products obtained per cwt. of starting paddy at 13.1 percent moisture was reduced 4 cents as a result of overdrying to 11.4 percent moisture before milling. However, if the low-moisture products could be satisfactorily remoistened to normal moisture level, value of remoistened milled products per cwt. of starting paddy at 13.1 percent moisture would be 7 cents above normal.

<u>Remoistening Low-Moisture Milled Rice</u>. Because weight loss in overdrying is so important, laboratory tests were made on remoistening of low-moisture head rice. Head rice was restored to normal moisture content by exposing it to humidified air moving at various velocities. Remoistening was accomplished with little change in breakage, cracking, chalkiness, or color of kernels. Thus we concluded that rice can be remoistened without damage.

<u>Time Lag Between Drying and Milling</u>. A well-mixed lot of rice was dried to 13 percent moisture and samples milled in a laboratory mill after different time intervals. Milling results, which show a sharp decrease as the time lag increases from 1 to 8 hrs. were as follows:

Time lag between drying and milling, hours	Head yield, percent	Total yield, percent
1	60.9	71.3
8	56.8	70.6
19	56.0	70.9
24	56.5	70.5
48	55.5	70.2

Conclusions. The three variations in drying and milling procedure discussed here may be found useful in various combinations, depending on facilities and conditions existing at the particular plant.

Our plant test data on overdrying indicate that for each cwt. of paddy of normal moisture content the value of milled products could be increased 7 cents by overdrying if the milled products were subsequently remoistened. There are indications that the increase in value would be considerably higher than 7 cents if the rice were milled immediately after overdrying. Increased costs involved in overdrying, milling, and remoistening would partially or completely offset a 7-cent gain in value. Each plant operator will have to determine whether overdrying prior to milling would be profitable in his particular plant.

PARBOILING CONDITIONS FOR CALROSE RICE

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Under the terms of a Public Law 480 agreement with India (May 10 issue of Rice Market News), 22 million cwt. of milled U. S. rice will be sold to that country over a 4-yr. period. A considerable portion of the shipments will probably be parboiled rice, which India consumes in large quantities. India prefers the long grains, but California Calrose is acceptable. With the object of advising individuals and rice milling companies who wish to install parboiling equipment for supplying Indian or other contracts, this Laboratory has conducted preliminary studies to define conditions under which Calrose rice can be parboiled satisfactorily.

Rough rice is parboiled by soaking in water and then pressure-cooking to gelatinize the starch completely. The rice is then dried and milled. Both the soaking and cooking steps are critical with respect to the properties of the milled product, particularly its appearance and the yield of head rice.

Soaking. Good results were obtained with two lots of Calrose when the rough rice was soaked at 132° F. for 5 hrs. to increase its moisture content to about 32 percent or at 150° F. for 4 hrs. to a moisture content of 36 percent. Nearly equal results were obtained when the rough rice was soaked until its moisture content reached about 32 percent (2 hrs. at 150° F.), and then drained and allowed to "temper" for 2 or 3 hrs. while the water distributed itself evenly throughout the kernels. With a third lot of Calrose, the uptake of moisture was more rapid, and soaking time of 4 hrs. at 132° F. or 3 hrs. at 150° F. was adequate. Variations in properties of different lots of rough rice apparently may be important in choosing specific conditions for soaking.

While various combinations of soaking and tempering times and temperatures proved satisfactory for adequate uptake and distribution of water through the kernels, poor results were obtained at soaking temperatures above the gelatinization point of the starch. In the case of Calrose, this is about 153° F. Above this temperature, water absorption was excessive. Some kernels burst through the bran layers and hull, and the whole mass became sticky and slimy.

Incomplete soaking or tempering is reflected in excessive breakage of kernels when the rice is cooked, dried, and milled. For example, Calrose rice soaked at 150° for 2 hrs. followed by 1 hr. of tempering, before it was cooked and dried, yielded more than 30 percent broken kernels in the standard milling test.

Cooking. With properly soaked, drained, and tempered rice, thorough gelatinization of the starch was obtained by cooking with live steam at 20 lbs. per sq. in. gauge pressure for 5 to 8 min. Equally good results were obtained by cooking at 30 and 40 lb. pressure for shorter times, but at these higher pressures particular care must be taken to avoid overcooking, as the kernels darken rapidly. The cooking may be carried out either in batches or continuously in suitable pressure equipment. The cooked rice was dried at 120° F. in a crossflow air dryer to a moisture content of 12 to 14 percent. A few trials indicated that other types of dryers would be satisfactory. The dried rice was shelled and milled in conventional equipment.

The samples of Calrose yielded 71 to 72 percent milled rice and 48 to 64 percent head rice before cooking, and 70 to 75 percent milled rice and 55 to 65 percent head rice, when properly parboiled.

AIR-CLASSIFICATION MILLING

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In protein-deficient global areas where rice is a main constituent of the dietary, a need exists for rice products of higher protein content than is commonly found in the milled grain. Attainment of such protein-rich foods may be possible by applying a process known as turbomilling to rice flours.

This process is being successfully used on wheat flours in about six commercial plants, which produce 20 percent protein flours from 10 percent starting material. The equipment consists of (1) impact or turbulence grinders which reduce the flour as nearly as possible to single starch-granule size and (2) air-classifiers which segregate the flours into fractions of varying degrees of fineness, the finer fractions being richest in protein. Thus good high-protein bread flours and low-protein cake flours are obtained from certain wheats which alone are not very good for either use. Low-cost, low-protein starches can also be obtained by this type of system.

Recent preliminary cooperative work by the Southern, Northern and Western regional laboratories on long, medium, and short grain rices has demonstrated that this procedure can be used on rice flours to obtain disproportionation of protein among the air-classified fractions of finely ground rice. However, because rice-starch granules, which are embedded in protein, are much smaller in size than those of other cereals, the separation of protein-rich from protein-poor material is more difficult and will probably require intensive research to solve the problem. With proper methodology and by use of high-protein rices as starting material, we envision obtaining rice flour fractions with 15 to 20 percent protein. These may well fit into the preparation of synthetic milks to feed the hungry children of the world, and might also be suitable for meat-like products to be sold in Central Europe, South America, and Asia.

USES FOR RICE HULLS

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Present uses for rice hulls, either whole or comminuted, are as follows:

(1) In agriculture and food processing (a) as nesting or bedding material for livestock, (b) as a diluent in fertilizer, (c) as a channeling aid in fruit juice processing, (d) as a soil conditioner, (e) in potato and small seed planting, and (f) as a constituent of feeds;

(2) In metal industries (a) in production of casting and (b) as a blast cleaner for airplane and automotive parts;

(3) Miscellaneous (a) as an extender for plywood glues and (b) in roasting of chromite ores for production of sodium bichromate.

More important from a tonnage standpoint than rice hulls is rice hull ash, which is presently used principally as a grease adsorbent in garages and service stations. Some is used in the manufacture of soaps, as a filtering medium, and in ceramics.

Other past and proposed uses for rice hulls were discussed as follows:

(a) for production of gas, charcoal, tar, and acetic acid by dry distillation, (b) as a source of alpha-cellulose and furfural, (c) for production of decolorizing chars, (d) for production of alcohol, (e) for production of light-weight building materials, (f) as boiler fuel, and (g) as a constituent of thermoplastic resins.

Although rice hulls have been used for production of furfural, their pentosan content is low (12%) as compared with that of oat hulls and corn cobs (22%). A process developed in Sacramento yields about 7.7 percent recoverable furfural from rice hulls, and a white fibrous product that is more than 98 percent alpha-cellulose. Cost of a plant large enough for economical operation (20-22 tons of furfural and 90 tons of alpha-cellulose a day) would be about 5.5 million dollars.

The use of rice hulls in feeds is recent, but in California production of a feedstuff from the total offal of a rice mill is in the range of 90 tons a day. Potential production is 400 tons a day. This development started with experimental feeding tests at the University of Arkansas in 1951-55, aided by the Arkansas Rice Growers Cooperative. The name "rice mill byproduct" was proposed by the Association of American Feed Control Officials for the entire byproduct obtained in the milling of rice including hulls, bran, polish, and broken grains. It is sometimes called "rice mill feed", and is described by Professor F. B. Morrison in his manual <u>Feeds and Feeding</u>.

This outlet for hulls is attractive to rice millers because it eliminates the separate handling of individual byproducts in the plant, reduces the bran rancidification problem, and permits establishing a selling price for the feed based on nutritional values.

RICE BRAN PRODUCTS

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The production potential of rice bran in California and the United States, on the basis of current rice acreage, appears to be about 70,000 tons per year in California and in excess of 200,000 tons per year for the United States, based on average milling.

The annual production of oil from rice bran by the two existing extraction plants in the United States approximates 10 million pounds, with a potential of not more than 50 million pounds. This is a small volume of oil in view of an annual production of 10 billion pounds of fats and oils in the United States. If the bran from rice grown in the whole world were extracted, an annual yield of not more than 5 billion pounds of rice oil would result and amount to little more than the annual United States production of soybean oil. Rice oil has sold in a range of 7 to 17.5 cents a pound of clarified crude during the past 10 years in competition with soybean and cottonseed oil. The lower part of the range results in little more than a break-even basis. However, benefits accrue due to the improved stability of the resulting meal, permitting more orderly marketing of the end products.

Rice bran offers good value to animal and poultry feeders as a result of its good protein quality as shown by Kik, but it can be improved by the addition of lysine, threonine and vitamin B_{12}. In addition, rice bran has good vitamin and mineral values. Rice bran is used in mixed feeds as a replacement for wheat mill-run bran on a pound-for-pound basis.

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